Marmota vancouverensis. By David W. Nagorsen

Marmota vancouverensis Swarth, 1911

Vancouver Marmot

Marmota vancouverensis Swarth 1911:201. Type locality Mount Douglas (=Douglas Peak), 4,200 ft, Vancouver Island, British Columbia, Canada.

CONTEXT AND CONTENT. Order Rodentia, Suborder Sciuromorpha, Family Sciuridae, Subfamily Marmotinae, Genus *Marmota*. Thirteen species are recognized in the genus; six are found in North America (Honacki et al., 1982). According to Hoffmann et al. (1979) and Howell (1915) the North American species can be classified into four species groups: the *monax* group (includes *M. monax*), the *flaviventris* group (includes *M. flaviventris*), the *broweri* group (includes *M. broweri* and the Old World species *M. camtschatica*), and the *caligata* group (includes *M. caligata*, *M. olympus*, and *M. vancouverensis*). No subspecies are recognized in *M. vancouverensis*.

DIAGNOSIS. Species of the *caligata* group can be distinguished externally from other species of *Marmota* by the grizzled black to brown pelage, larger size, and the circular or subcircular shape of the two posterior plantar pads on the sole of the hind foot; the deeper angular process of the mandible; and the more prominent sagittal and lambdoidal crests that are diagnostic cranial characters of the *caligata* group (Hoffmann et al., 1979; Howell, 1915).

Marmota vancouverensis differs from *M. caligata* and *M. olympus* by having dark brown to nearly black dorsal and ventral pelage; frontal bones of the cranium that project forward creating a V-shaped notch between the nasals; a mandible with a thinner more recurved coronoid process and a less concave lower margin; and a smaller P3 (Hoffmann et al., 1979; Howell, 1915).

Marmota vancouverensis is the only species in the genus that inhabits Vancouver Island.

GENERAL CHARACTERS. Color descriptions given here are based on study skins in the collections of the Museum of Vertebrate Zoology, University of California, Berkeley; British Columbia Provincial Museum; and the Cowan Vertebrate Museum, University of British Columbia. New adult pelage varies from Sepia (color names from Smithe, 1975, 1981) to Fuscous on the dorsum, and from Sayal Brown to Sepia on the venter. Most of the long guard hairs are brown and monochromatic, although some appear paler in the basal area. None of the guard hairs in *M. vancouverensis* are distinctly tricolored as in *M. caligata* (Hoffmann et al., 1979). Some guard hairs are completely white. White hairs (Fig. 1) are most abundant on the nose, forehead, and chin where they form solid white markings. Isolated white hairs are distributed sparsely over the dorsum, but are more concentrated on the venter; their abundance and distribution are variable. In some individuals the white hairs form a white streak on the center of the chest and abdomen; in other animals the white hairs on the venter are more diffuse.

Old, faded pelage is much paler, ranging from Tawny Olive to Ground Cinnamon. White hairs are less conspicuous in animals with old, faded pelage. Although Hoffmann et al. (1979:9) described the pelage of *M. vancouverensis* as "uniform dark brown both dorsally and ventrally," most adults, particularly during summer, are variegated in appearance with patches of old faded and new dark fur. This mottled appearance, extremely variable among individuals, can be attributed to incomplete molting. Juvenile pelage is woolly and uniformly dark (Sepia).

Hoffmann et al. (1979) interpreted the pelage color of *M. vancouverensis* as a form of melanism that became fixed in a small isolated population. Evidently the pelage in some populations of *M. caligata* is similar to that in *M. vancouverensis*. Heller (1909) and Howell (1915) described melanic specimens of *M. caligata* from

Glacier Bay, Alaska, that closely resemble *M. vancouverensis* in color and white markings.

The body of *M. vancouverensis* is thickset with short legs and a short broad head. The tail is about 33–46% of the total body length, and is densely haired. Feet are pentadactyl and robust with stout, slightly recurved fossorial claws. The pollex is the longest digit, the second and fourth toes are subequal, and the fifth is shorter. The sole of the forefoot has three pads at the base of the digits and two larger posterior pads. The third digit of the hind foot is slightly longer than the second and fourth; fifth and first digits are short. The hind foot has six plantar pads: four anterior pads at the base of the toes and two circular posterior pads. Hoffmann et al. (1979:12) noted, "*Marmota caligata* and *M. olympus* (and probably *vancouverensis*) appear to be unique in the genus in that the two posterior pads are both nearly circular in shape." Usually five pairs of mammae are present. The cheek pouch is rudimentary and lacks retractor muscles. Morphology of the baculum of *M. vancouverensis* has not been studied.

The skull of *M. vancouverensis* is nearly straight in superior outline (Fig. 2). The interorbital region is wider than the postorbital region; nasals are narrowed posteriorly. There is a V-shaped notch at the proximal ends of the nasals. In mature adults, the temporal ridges unite to form a pronounced sagittal crest. The anterior portion of the floor of the basioccipital is nearly flat and bordered

FIG. 1. Adult female *Marmota vancouverensis*, Green Mountain, Vancouver Island, British Columbia, July 1980. Photo by William Merilees.
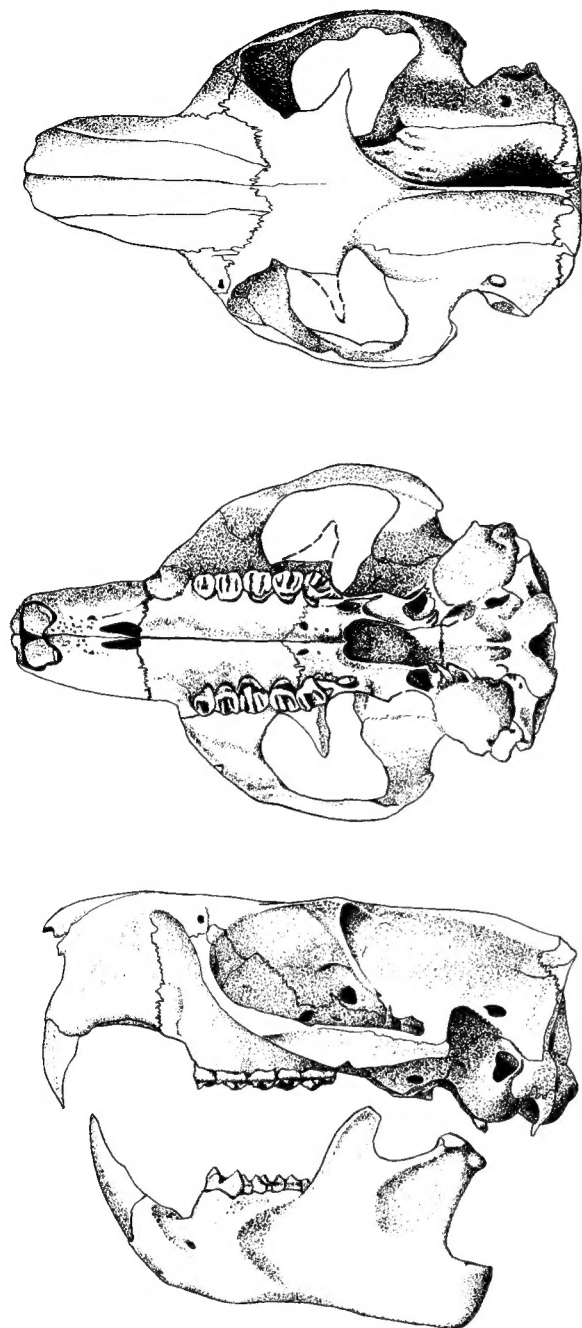
FIG. 2. Dorsal, ventral, and lateral views of the skull and lateral view of the mandible of an adult male *Marmota vancouverensis* (BCPM 1260).

posteriorly by two low processes that unite near the center of the basioccipital. The palate is beveled at its posterior border and the interpterygoid fossa are relatively narrow. The maxillary toothrow diverges anteriorly (Fig. 2). Color of the anterior face of the incisors varies from white to pale yellow. The dental formula is i 1/1, c 0/0, p 2/2, and m 3/3, total 24. Dental characters include: a P4 as large or larger than M1; cheek teeth high crowned; metaloph complete on each upper molar, and on M3 joins the posterior cingulum; a molariform p4 with a transverse crest between protoconid and parametaconid forming the protolophid; and m1 and m2 parallelogram-shaped in occlusal outline.

Males average larger than females in external and cranial measurements. Means and standard errors ($\bar{X}\pm SE$) of selected measurements (in mm; external measurements from museum skins, cranial measurements from Hoffmann et al., 1979) for adult males and females, respectively, are as follows: total length, 695±13.4, $n = 6$, 661±11.4, $n = 12$; length of tail vertebrae, 220±16.1,
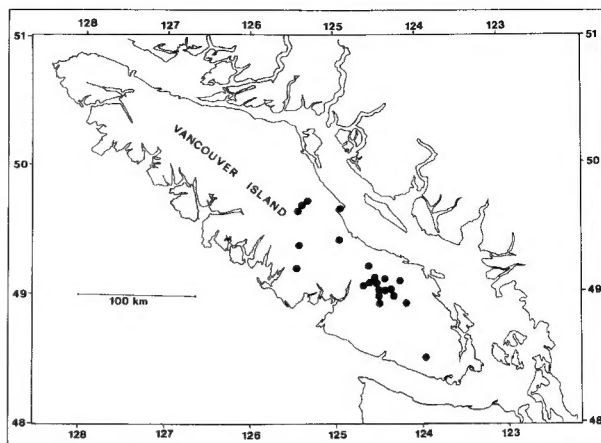

FIG. 3. Historical distribution of *Marmota vancouverensis*. Locality records are based on museum specimens and unpublished sightings. Modified from Heard (1977).

$n = 6$, 193±6.0, $n = 12$; length of hind foot, 97±2.2, $n = 6$, 96±2.5, $n = 12$; length of ear, 30, $n = 5$, 28±1.0, $n = 7$; condylobasal length, 100.3±1.1, $n = 4$, 92.7±0.7, $n = 10$; length of maxillary toothrow, 24.7±0.3, $n = 4$, 23.7±0.2, $n = 10$; length of nasal, 41.5±0.7, $n = 4$, 38.8±0.6, $n = 10$; width of rostrum 23.7±0.1, $n = 4$, 21.8±0.3, $n = 10$; zygomatic width, 64.6±0.4, $n = 4$, 60.7±0.6, $n = 10$; interorbital width, 24.3±0.4, $n = 4$, 22.3±0.4, $n = 10$; length of angular process, 53.1±0.4, $n = 4$, 49.6±0.8, $n = 10$; mastoid width, 46.3±0.3, $n = 4$, 42.8±0.4, $n = 10$.

According to Heard (1977) body weights of adult *M. vancouverensis* range from about 3.0 kg in May to 6.5 kg in September. Males are significantly heavier than females.

DISTRIBUTION. This species is endemic to Vancouver Island, British Columbia, Canada (Fig. 3). Historical distributional records (Cowan and Guiguet, 1965; Heard, 1977) and known active colonies are confined to mountains in the central and southern part of Vancouver Island. Prehistoric distribution of *M. vancouverensis* is unknown.

FOSSIL RECORD. No fossils are known for this species. Oldest known specimens are faunal remains from an archeological site at Shoemaker Bay, Alberni Inlet, that were dated at about 1500 B.P. (Calvert and Crockford, 1983). Hoffmann et al. (1979) suggested that *M. vancouverensis* is a Pleistocene isolate derived from mainland populations of *M. caligata*. Similarly, Heard (1977) and McCabe and Cowan (1945) hypothesized that *M. vancouverensis* survived the last glaciation in refugia on Vancouver Island. Nonetheless, fossil evidence is needed to confirm the existence of *M. vancouverensis* on Vancouver Island during the Pleistocene. *M. vancouverensis* could have colonized Vancouver Island after the Pleistocene.

ONTOGENY AND REPRODUCTION. There have been no comprehensive studies on the reproductive biology of this species. Mating presumably occurs above ground during the first 3 weeks after emergence from hibernation (Barash, 1973; Holmes, 1984). The gestation period has not been determined but it is probably 28 to 33 days as in other North American species of *Marmota* (Armitage, 1981; Lee and Funderburg, 1982). Based on limited data, Heard (1977) speculated that females produce young in alternate years similar to *M. olympus*. However, in the closely related species *M. caligata*, litters of a female may be spaced 2, 3, or even 4 years apart (Holmes, 1984). Heard (1977) reported an average litter size at emergence of 3.0 ($n = 5$). Milko (1984) observed litters at emergence of 4.6 ($n = 5$) in 1981 and 2.7 ($n = 6$) in 1982; he attributed these differences in litter sizes to variation in winter snow depth and spring snowmelt. Dates of birth and length of the nursing period are unknown. Juveniles emerge from the burrow in late June or July (Heard, 1977). This species appears to have delayed maturity as in *M. olympus*. *M. vancouverensis* probably does not breed until 3 years of age. Heard (1977) noted that the growth rates of *M. vancouverensis* are similar to those of other marmots,

and he attributed the lengthy maturation period in this species to its relatively large adult body size. Heard (1977) classified individuals into four age groups by body mass: infants, yearlings, 2 year olds, and adults (at least 3 years old). Body mass in all age groups increases linearly from time of emergence in spring, until the onset of hibernation in autumn.

FORM AND FUNCTION. According to Heard (1977) the molt begins in midJuly with new fur first appearing on the forelegs and shoulders. Growth of new pelage on the rest of the body is extremely variable but usually the last areas to molt are the back of the head, tail, and rump. Some individuals do not complete their molt before hibernation in late September; they emerge from hibernation in spring at the same stage of molt as the previous autumn. In these individuals, no hair growth occurs until the molt begins in July and the new molt begins in regions that had not completed the molt during the previous year. Heard (1977) reported that juveniles emerge from the burrow with black fur and do not seem to molt during their first summer. However, Hoffmann et al. (1979) noted that juvenile *M. caligata* and *M. camtschatica* emerge from the burrow with a dense woolly pelage that is shed gradually and replaced with longer, coarser hair.

The hibernation period is 7 to 8 months and extends from early October to early May. Data are insufficient to assess sex or age differences in the length of the hibernating period. There have been no studies of the physiology of *M. vancouverensis*.

ECOLOGY. Altitudinal range is 1,100 to 1,450 m. Subalpine herbaceous communities with steep slopes (Fig. 4) support the largest populations of *M. vancouverensis*. Common plants in these communities include: *Abies lasiocarpa*, *Tsuga mertensiana*, *Chamaecyparis nootkatensis*, *Vaccinium* sp., *Leutkea pectinata*, *Alnus sinuata*, *Erigeron peregrinus*, *Rhododendron albiflorum*, *Phlox diffusa*, *Anaphalis margaritacea*, *Aster foliaceus*, *Lupinus latifolius*, and *Pteridium aquilium* (Heard, 1977; Milko, 1984). Lush forb-grass meadows such as those found at Haley Lake are rare on Vancouver Island; they generally are restricted to steep south-facing slopes where avalanches and snow creep inhibit the growth of trees (Milko, 1984). Avalanches and snow creep in these meadows also promote rapid snowmelt and early appearance of forage in spring. Andersen et al. (1976) hypothesized that reproductive success in female marmots that establish home ranges in areas where forage appears early in the season is enhanced. Fire also contributes to the formation of open subalpine communities that support *M. vancouverensis* (Milko, 1984). Although the largest concentrations of *M. vancouverensis* are in open subalpine habitats, active burrows and colonies with young have been found in forest, logging slash, cut timber, under buildings and other manmade structures, road banks, and cleared ski runs. It is uncertain if marmots occupying these habitats are permanent residents or dispersing individuals.

Marmota vancouverensis is colonial. Average colony size in spring before young-of-the-year emerge from the burrow is about eight animals (Heard, 1977). The mating system in other North American marmots may be monogamous (for example, *M. caligata*) or polygynous with males maintaining harems of two or three females (e.g., *M. caligata*, *M. olympus*, *M. flaviventris*; Barash, 1973, 1974a; Downhower and Armitage, 1971; Holmes, 1984). Holmes (1984) hypothesized that the breeding ratio of females to males in a marmot colony was determined by food and hibernacula resources. The mating system of *M. vancouverensis* has not been studied but observations by Heard (1977) on two colonies at Haley Lake in 1974 suggest that the species is monogamous. One colony had four animals: an adult male, adult female, a 2-year-old female, and a yearling male. The second colony consisted of two groups of marmots that were segregated spatially. One group had an adult male and adult female; the other group consisted of an adult male, adult female, two 2-year-olds, and three yearlings. In addition, a yearling female associated with both groups in the colony and an adult of unknown sex that inhabited a peripheral area. However, from his estimates of vegetation biomass, Milko (1984) predicted that the colonies at Haley Lake should exhibit some degree of polygyny.

In response to a growing awareness of *M. vancouverensis* by the public, the British Columbia Ministry of Environment designated this mammal as an endangered species in 1980. Estimates of numbers and sizes of colonies before the early 1970's are not available, thus there is little evidence that populations of this species have

FIG. 4. Subalpine meadow habitat at Haley Lake, Vancouver Island. This site was the study area of Heard (1977) and Milko (1984). Photo by D. W. Nagorsen.

declined throughout its range. Based on limited data, the total population of *M. vancouverensis* was estimated in the late 1970's at 50 to 100. In 1982, the British Columbia Ministry of Environment initiated a systematic inventory of *M. vancouverensis* colonies. The precise number of colonies is still unknown but data from recent inventories indicate that the total population ranges from 200 to 300. Moreover, these surveys revealed that populations of *M. vancouverensis* have increased at several sites since the 1970's. Previously unknown colonies were found during inventories of 1982 and 1983. Because large areas of Vancouver Island have not been surveyed, it seems likely that more colonies will be found.

According to Heard (1977) and Milko (1984) the diet of *M. vancouverensis* includes fruits of *Arctostaphylos uva-ursi*, *Thalictrum occidentale*, *Vaccinium* sp.; fronds of *Pteridium aquilinum*, leaves and flowers of *Campanula rotundifolia*, *Aquilegia formosa*, *Thalictrum occidentale*, *Lupinus latifolius* (=*L. arcticus*), *Heracleum lanatum*, *Phlox diffusa*, *Castilleja miniata*, *C. hispida*, *C. parviflora*, *Valeriana sitchensis*, *Lathyrus nevadensis*, *Arenaria macrophylla*, *Eriophyllum lanatum*, *Erythronium grandiflorum*, *Lilium columbianum*, *Veratrum viride*, *A. uva-ursi*, *Vaccinium* sp., *Carex* sp., and various species of grasses. Most important plants in the diet are the forbs *L. latifolius*, *T. occidentale*, *L. nevadensis*, *C. miniata*, *C. hispida*, *H. lanatum*, and *P. diffusa* and species of graminoids (Milko, 1984). Graminoids are the most important food in early spring; the summer diet is composed mainly of forbs. These seasonal changes in diet reflect the availability of plants and selection of species by *M. vancouverensis* (Milko, 1984).

Predation on *M. vancouverensis* has not been studied but potential predators include the gray wolf (*Canis lupus*), marten (*Martes americana*), wolverine (*Gulo gulo*), cougar (*Felis concolor*), black bear (*Ursus americanus*), red-tailed hawk (*Buteo jamaicensis*), northern goshawk (*Accipiter gentilis*), golden eagle (*Aquila chrysaetos*), great-horned owl (*Bubo virginianus*), and bald eagle (*Haliaeetus leucocephalus*; Heard, 1977).

The only ectoparasites identified from *M. vancouverensis* are *Thrassis spenceri spenceri*, a common flea of the *M. caligata* group (Holland, 1985) and an undetermined species of *Ixodes* (Heard, 1977). Helminthes found in *M. vancouverensis* include the nematode *Balyisascaris laevis* (Mace and Shepard, 1981) and the cestodes *Diandyra composita* (Rausch and Rausch, 1971) and *D. vancouverensis* (Mace and Shepard, 1981). *D. composita* is known from all Nearctic *Marmota* except *M. monax*; *D. vancouverensis* has been recorded only from *M. vancouverensis*.

BEHAVIOR. According to Heard (1977), activity of *M. vancouverensis* generally is bimodal with most activity in mornings and evenings and least at midday; the bimodal pattern is most evident in June, July, and August. Outside the burrow, individuals spend most of their time resting or feeding. The total time spent feeding decreases throughout the summer. Activity is reduced when temperatures exceed 20°C and the time spent in the burrow at midday is correlated directly with maximum daily temperature.

Vocalizations made by *M. vancouverensis* include whistles,

hisses, rapid chirps, screams, growls, and "kee-aw" calls (Heard, 1977). Whistles that ranged from 0.20 to 0.84 s in duration are used as alarm calls (Heard, 1977). Whistles have three harmonics: the first harmonic (2,910±33 Hz), the dominant frequency; a second harmonic at about 5,700 Hz; and a third at about 8,400 Hz. Heard (1977) classified whistles into three categories: long (mean duration 0.57 s), medium (mean duration 0.26 s), and short (mean duration 0.20 s). Short whistles usually are given in the presence of avian predators; long whistles are a response to mammalian predators. Medium whistles are used infrequently by *M. vancouverensis*. Intensity of whistles is variable and the reaction of *M. vancouverensis* to alarm calls is correlated with the intensity of whistles. A two-syllable "kee-aw" call may represent a state of uneasiness or low intensity alarm (Heard, 1977). This call has a fundamental frequency that changes in two stages from 1,912± 39 to 1,109±57 Hz, and two harmonics less intense than the fundamental frequency. The vocalizations of *M. vancouverensis* are most similar to those of *M. caligata* and *M. olympus*. Except for minor differences in frequency and harmonic structure, the long, medium, and short whistles of *M. vancouverensis* resemble closely the long call, descending-ascending calls, and chirps described for *M. caligata* (Heard, 1977; Taulman, 1977). The long call of *M. olympus* is shorter in duration than the long calls of *M. vancouverensis* and *M. caligata* and it lacks harmonics (Barash, 1973). According to Heard (1977) the "kee-aw" call of *M. vancouverensis* corresponds to the low frequency call of *M. caligata* described by Taulman (1977). Heard (1977) concluded that the medium call of *M. olympus* (Barash, 1973) is homologous with the "kee-aw" call of *M. vancouverensis*, although the two sounds differ in frequency and harmonic structure.

Heard (1977) classified social interactions among Vancouver marmots into 13 distinct behavioral patterns: greeting, anal sniffing, play-fighting, chasing, mounting, alert, avoidance, tail raising, lunging, suckling, social grooming, play-fight invitation, and play-chasing. Similar behavioral patterns have been described for other species of North American marmots (Barash, 1973, 1974a; Frase and Hoffmann, 1980). Rates of all behavioral patterns in *M. vancouverensis* are greatest in June and decline throughout July, August, and September. These behaviors are used by all age-sex classes in about the same proportion. Greeting and play-fighting are the most common behavior. They are reciprocal acts with interacting individuals behaving similarly. Greeting is characterized by two or more marmots touching noses or an animal sniffing the cheek, ear, or flank of another marmot. Play-fight consists of two marmots standing on their hind legs and pushing with their forelimbs against the chest or shoulder of the other animal. Chasing, avoidance, and lunging are agonistic behaviors; they are good indications of dominance relationships among individuals. Lunging and chasing are characteristic of the dominant individual in an encounter; avoidance is characteristic of subordinate individuals. Tail raising, play-fight invitation, mounting, social grooming, and alert also may indicate dominance status. The dominance hierarchy in decreasing order of dominance is adult males, adult females, 2-year-old females, yearling females. *M. olympus* has a similar hierarchy (Barash, 1973). According to Heard (1977) both adult male and female *M. vancouverensis* are territorial; territories are delimited by scent marking with cheek glands. Only adult males, adult females, and 2-year-old females scent mark; most scent marking is by adult males. In other marmots (for example, *M. olympus*, *M. flaviventris*) scent marking occurs also in nonterritorial animals and in these species scent marking has been interpreted as an expression of social dominance (Armitage, 1976; Barash, 1973).

Barash (1974b) hypothesized that the degree of sociality, that is, social tolerance, in species of *Marmota* was related to the length of the vegetative growing season. According to this hypothesis, in severe environments with short growing seasons relative growth rates of marmots are slow and sexual maturation is delayed. Greater social tolerance in such environments is advantageous because it permits dispersal of young to be delayed until the third summer when animals are near adult size. Heard (1977) concluded that his data for *M. vancouverensis* did not support the hypothesis. Although the growing season experienced by *M. vancouverensis* (93 to 121 days) is similar to that of *M. flaviventris*, sociality and reproduction in *M. vancouverensis* are most similar to that of *M. olympus*, a species that inhabits environments with a shorter growing season (40 to 70 days). Moreover, Heard (1977) attributed the delayed maturation in *M. vancouverensis* to its large size rather than a slow growth rate. Data presented by Andersen et al. (1976) for *M. flaviventris* also contradict the correlation between growing season and growth rate proposed by Barash (1974b). Other factors that may determine interspecific and intraspecific differences in sociality and social behavior in *Marmota* include food and hibernacula resources (Andersen et al., 1976; Holmes, 1984) and population dynamics (Armitage, 1977).

GENETICS. Based on one female, Rausch and Rausch (1971) reported a diploid number of 42 and a fundamental number of 60 for the karyotype of *M. vancouverensis*. Autosomes consist of three pairs of metacentrics, four pairs of submetacentrics, five pairs of subtelocentrics, and nine pairs of acrocentrics. The X-chromosome probably is submetacentric; morphology of the Y-chromosome has not been determined. Karyotypic data suggest a close affinity with *M. caligata*.

REMARKS. Because it is the only mammal species endemic to Canada classified as an endangered species, various governmental agencies and naturalist groups are concerned about management and protection of *M. vancouverensis*. Nonetheless, the basic biology of this species has not been studied as thoroughly as that of other North American species of *Marmota*. Comprehensive research on *M. vancouverensis* such as that conducted on *M. flaviventris* (reviewed by Frase and Hoffman, 1980) is needed. From a management perspective, highest priority is for more surveys of potential habitats on Vancouver Island to locate colonies and for long-term monitoring of individual colonies. Intensive study also is needed to determine the mating system within colonies, the optimal size of colonies for maximum reproductive success, characteristics of habitats that support optimally sized colonies, the amount of dispersal by various age and sex groups in a colony, and the role of dispersal in regulating populations and promoting gene-flow among local colonies.

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